2.—The changing ecology of Western Australian wheat production

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Abstract

The ecology of wheat production in Western Australia has changed considerably since the commencement of wheat breeding in 1902. The changes involved are numerous and include technological developments such as the application of artificial fertilizers, correction for trace element deficiencies, increased use of mechanization, herbicides and insecticides and, the introduction of subterranean clover, which encouraged changes in crop rotational practices.

Collectively the changes which have occurred led to greater diversification of farming systems and to the declining popularity of those cultivars that were previously adapted. Further changes in crop management practices are considered necessary if the cultivars which are currently dominant are to be replaced.

Introduction

Agricultural research commenced in Western Australia in 1894 with the establishment of the Bureau, later the Department of Agriculture (Anon. 1967). Since then, under the guidance provided and through the release of more adaptable cultivars, wheat production and the acreage sown to wheat have increased considerably (Figure 1a). In contrast, improvements on yield per hectare have been gradual (Figure 1b). In addition to these production statistics, which reflect considerable seasonal variability, changes have occurred in the regional distribution of the area sown to wheat, in the farming systems and rotational practices employed and, in crop management technology; including mechanization, fertilizer practices and herbicide use.

The purpose of this paper is to trace the agro-ecological changes which have occurred in wheat production in Western Australia and to examine their influence on cultivar adapability.

Historical

(a) Early Establishment

Wheat production commenced with the initial settlement (1826) using cultivars of English origin which were, relative to the growing conditions prevailing, late maturing (Berthoud, 1903). For this reason their cultivation was restricted to the south-west coastal areas where reasonable prospects for spring rainfall occur (Berthoud, 1905). The discovery of gold at Coolgardie (1892) and at Kalgoorlie (1894) provided the incentive for an increase in population and for the expansion of inland communication and rural water supplies. These events, in turn, encouraged an increased interest in agriculture which intensified following the decline in gold production, in 1903. As a result there was increased clearing of land despite limited agronomic information and the absence of suitable adapted cultivars. Research stations were established at Narrogin (1901), Nabawa (1902), Merredin (1907) and Avondale (1911). In 1905 G. L. Sutton, a contemporary and disciple of W. Farrer, was appointed Cerealist (later Director of Agriculture) and brought with him, from Wagga (N.S.W.), F_3 seed of the cross Gluyas x Bunyip which was to have a major impact on Australian and local wheat production for many years.

(b) Breeding and Cultivar Popularity

Continuous export of wheat commenced from Western Australia in 1907 largely due to the popularity of the cultivar Gluyas.[1] In 1915, from the cross Gluyas x Bunyip Sutton released Nabawa and by 1926 this cultivar occupied nearly 50% of the area sown to wheat; becoming in addition, the most popular cultivar in South Australia (1930-34) and in New South Wales (1930-35). In 1934 the supremacy of Nabawa gave way to Bencubbin; a cultivar derived from back-crossing Nabawa back to its Gluyas parent. (Figure 2). Bencubbin, which flowered earlier than Nabawa, proved even more popular, and with its relative Gluclub, dominated wheat production in Western Australia until 1945 as well as becoming the leading cultivar in South Australia and New South Wales throughout the 1940's.

The popularity of Bencubbin (and Gluclub) then declined somewhat in competition with Bungulla, an early flowering line selected from Bencubbin, and together, these various "Gluyas" descendants retained their popularity until the 1953/54 season. (Figure 2). In today's local terminology the relative flowering habits of the Nabawa, Bencubbin and Bungulla would be considered as late, late/mid-season and early, respectively. The original cultivars of English origin would, by comparison, be "very late".

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[1] A farmer selection in South Australia from Words' Prolific; itself a farmer's selection from the South African variety Du Toit.

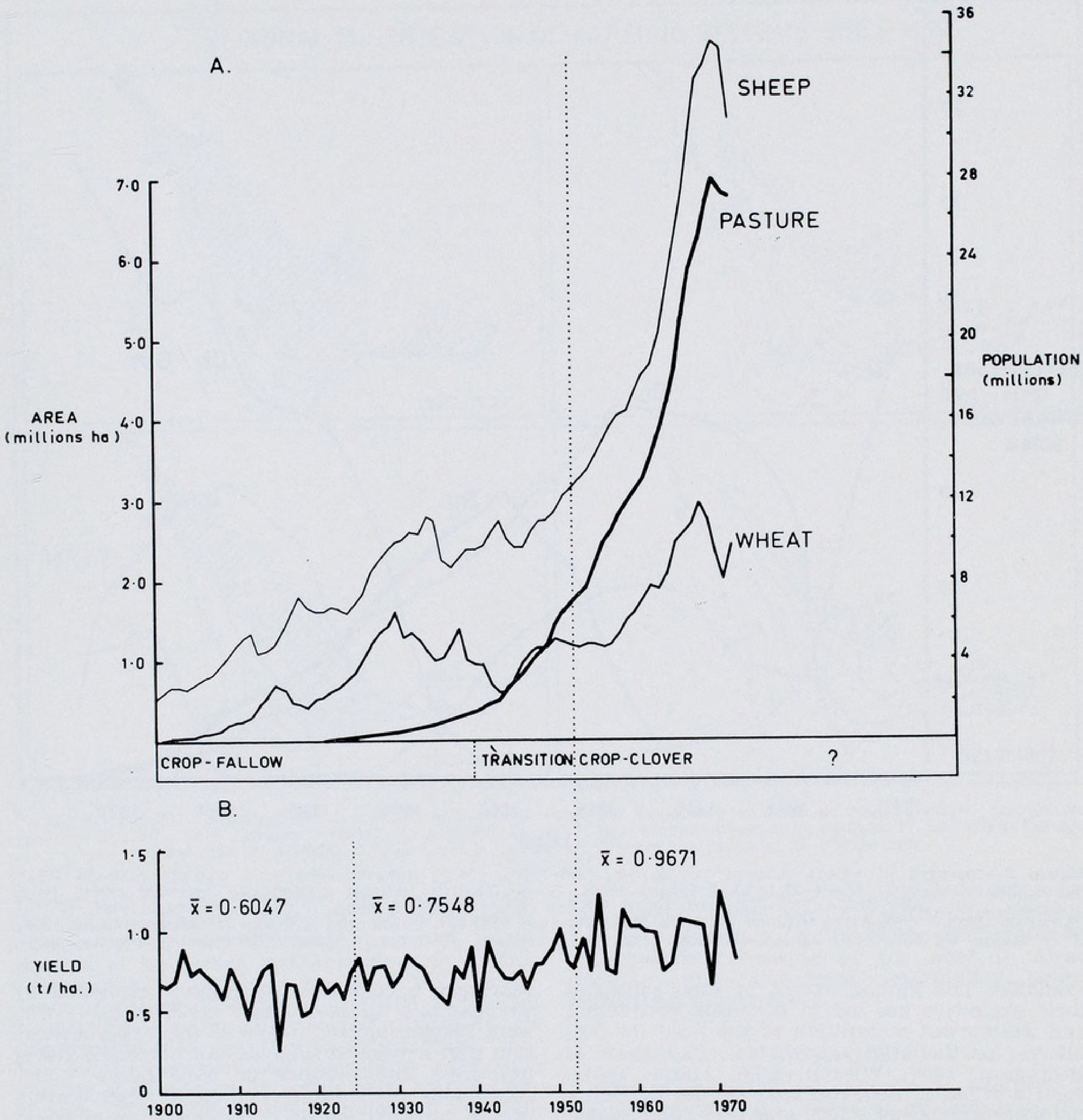

Figure 1.—(A) Changes in acreages sown to wheat and pasture and, in sheep population (1900-1972.)—(B) Variation in state average wheat yields (1900-1972).

The popularity of the "Gluyas" cultivars decreased with the introduction of early/mid-season flowering semi-dwarf cultivars bred in New South Wales and Victoria. These cultivars, Gabo and Insignia, first introduced in the early 1950's, and their respective descendants, Gamenya and Heron, steadily increased in popularity until pressure for reasons of quality reduced the popularity of Insignia and Heron.

This brief review draws to attention the demise of local cereal breeding, following a period of prolonged success, and a gradual shift toward earlier flowering cultivars of short-stature. This is interpreted as indicating a change in response to changes in the crop management practices under which wheat is grown in Western Australia and an attempt to account for it is presented below.

(c) Changes in Farming Systems and Cultural Practices

In the early days of settlement the differential land clearing of soils of high fertility led to sporadic settlement throughout those areas in which spring rainfall was sufficiently reliable to provide for the very late maturing cultivars then

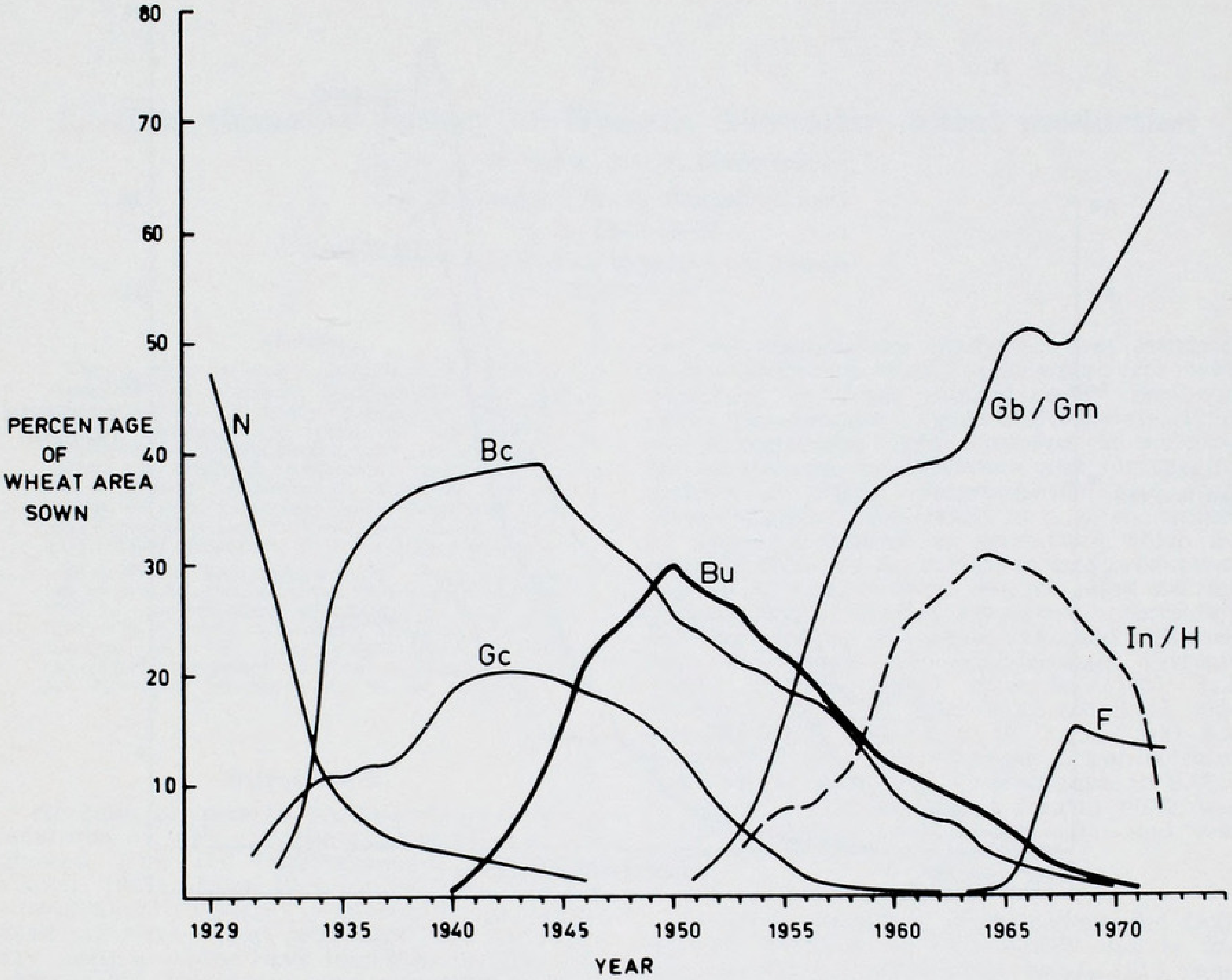

Figure 2.—Changes in wheat cultivar popularity (1929-1972). N = Nabawa (Gluyas x Bunyip—released 1915). Bc = Bencubbin (Gluyas x Nabawa—released 1929). Gc = Gluclub (Gluyas x Clubhead—released 1922). Bu = Bungulla (Sel^{n} from Bencubbin—released 1939). Gb = Gabo (Bobin x Gaza x Gular—released 1945). Gm = Gamenya (Gabo^{5} x Mentana//Gabo^{2} x Kenya 117A—released 1960). In = Insignia (Ghurka x Ranee—released 1946). H = Heron (R.D.R. x Insignia^{4}—released 1959). F = Falcon (Dundee x Gular^{2}//Bencubbin—released 1960).

available. The limited extent of such soils and their exploitive use led to declining production and widespread recognition of the need for fertilizers, particularly phosphates (Callaghan & Millington, 1956; Wicken, 1904; Mann, 1905). Such a trend is demonstrated by the declining yield/hectare between 1900 and 1925 (Figure 1b). However, the increasing availability of phosphate fertilizer and the release of more adaptable cultivars, as discussed above, arrested this trend and encouraged a further increase in the area sown to cereals (Figure 1a). This expansion was suspended temporarily during the years of the depression and World War II and, again, in 1968-71, due to the imposition of quotas.

During the 1920's and 30's cereal crops were managed with horse-drawn equipment under a crop-fallow rotation which permitted pre-season weed control and early seeding to which the late and late/mid-season cultivars then available were well adapted. Early flowering cultivars such as Sunset and Noongaar were released but attained little popularity. These generalizations represent a consensus of opinion expressed by Thomas and his co-workers (1926 to 1933) who were responsible for much of the experimentation that developed the basis for current cultural practices. The practice of bare fallow under continuous cultivation resulted in deterioration of the physical status of soils and emphasized the need to incorporate a pasture break in the rotation under a ley-farming system (Shier, 1956). At the time the availability of suitably adapted leguminous pasture cultivars was limited. The eventual release of sub-clover cultivars led to an exponential expansion of the pasture acreage (Figure 1a), a matching increase in sheep numbers (Figure 1a), increased soil fertility and a gradual conversion to crop-pasture rotational practices. A measure of these modifications on farming systems is provided by regional changes in the proportional utilization of cleared land for cereal crops (Figure 3).

The spread of sub-clover pastures and adoption of ley farming coincided with other significant technological events including the

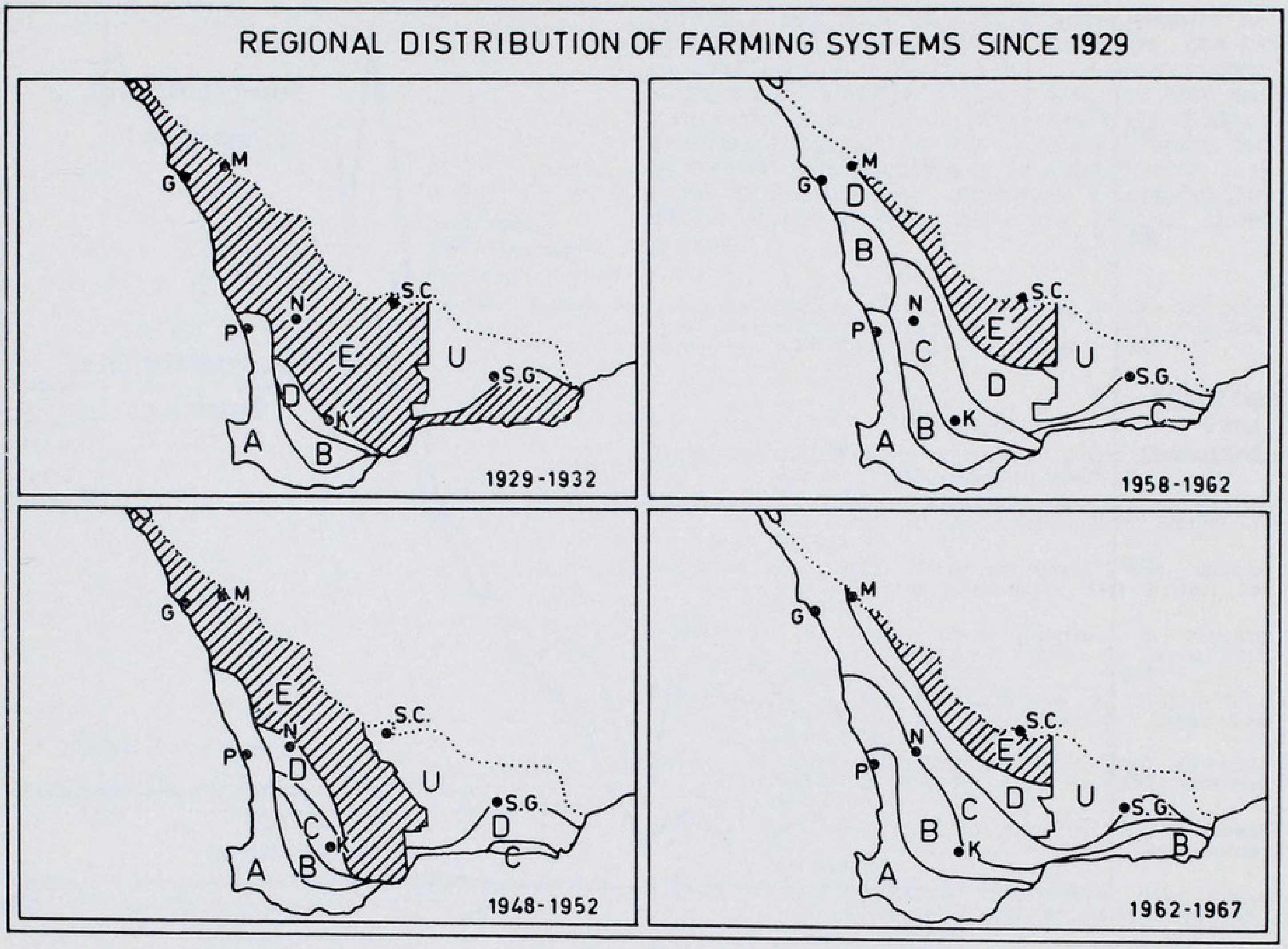

Figure 3.—Regional distribution of cropped acreage, at intervals from 1929 to 1967. A <10% Cereals, balance in pasture. B >10 <25% Cereals, balance in pasture. C >25 <50% Cereals, balance in pasture. D >50 <75% Cereals, balance in pasture. E >75 Cereals, (shaded) balance in pasture. U Unallocated.

recognition of, and correction for, trace element deficiencies (Burvill, 1965), the replacement of horsepower by mechanization and the introduction of herbicides and weedicides to control increased weed problems arising from the absence of fallow. The use of artificial fertilizers, principally superphosphate, has increased in conjunction with crop and pasture acreage. This has led to improved soil phosphate levels and further enhancement of soil fertility status, even though, from 1925 to 1960, application per unit area (ranging between 0.113 to 0.125 tonnes/ha has hardly altered. (Figures 4a and b).

The change in rotational practices together with the adoption of technological developments have stimulated more diversified farming systems (Figure 3) and, in more recent years, greater intensification within them—as evidenced by increased use of nitrogenous fertilizers (Figure 4). These developments have had numerous implications in the management of cereal crops; including the need to delay seed-bed preparation so as to conserve pasture for increased stock numbers and, a decrease in the use of cereal crops for purposes other than grain production i.e. for hay and stubble grazing purposes. Delay in seed-bed preparation has contributed to the later seeding of cereal crops and greater weed control problems—disadvantages which have been only partly compensated for by increases in soil fertility and increased mechanization because of the need to await opening rains and weed germination before cultivation can proceed.

Discussion

The introduction of leguminous pastures in particular, and the adoption of improved fertilizer and weed control technologies, have directly led to diversification of farming systems in Western Australia, and to changes in crop management practices. These changes include conversion from crop-fallow rotational practices favouring pre-season weed control, early seeding and the use of tall growing late to late/mid-season cultivars, to crop-pasture rotations characterized by increased soil fertility, increased weed problems, and an enforced delay in seedings to permit seed-bed preparation Under these circumstances short-stature cultivars of early to early/mid-season maturity have gained in popularity. (Figure 5). The sequence of events which has occurred represents a classical case history of changes in cultivar adaption because, at no stage has disease or con-

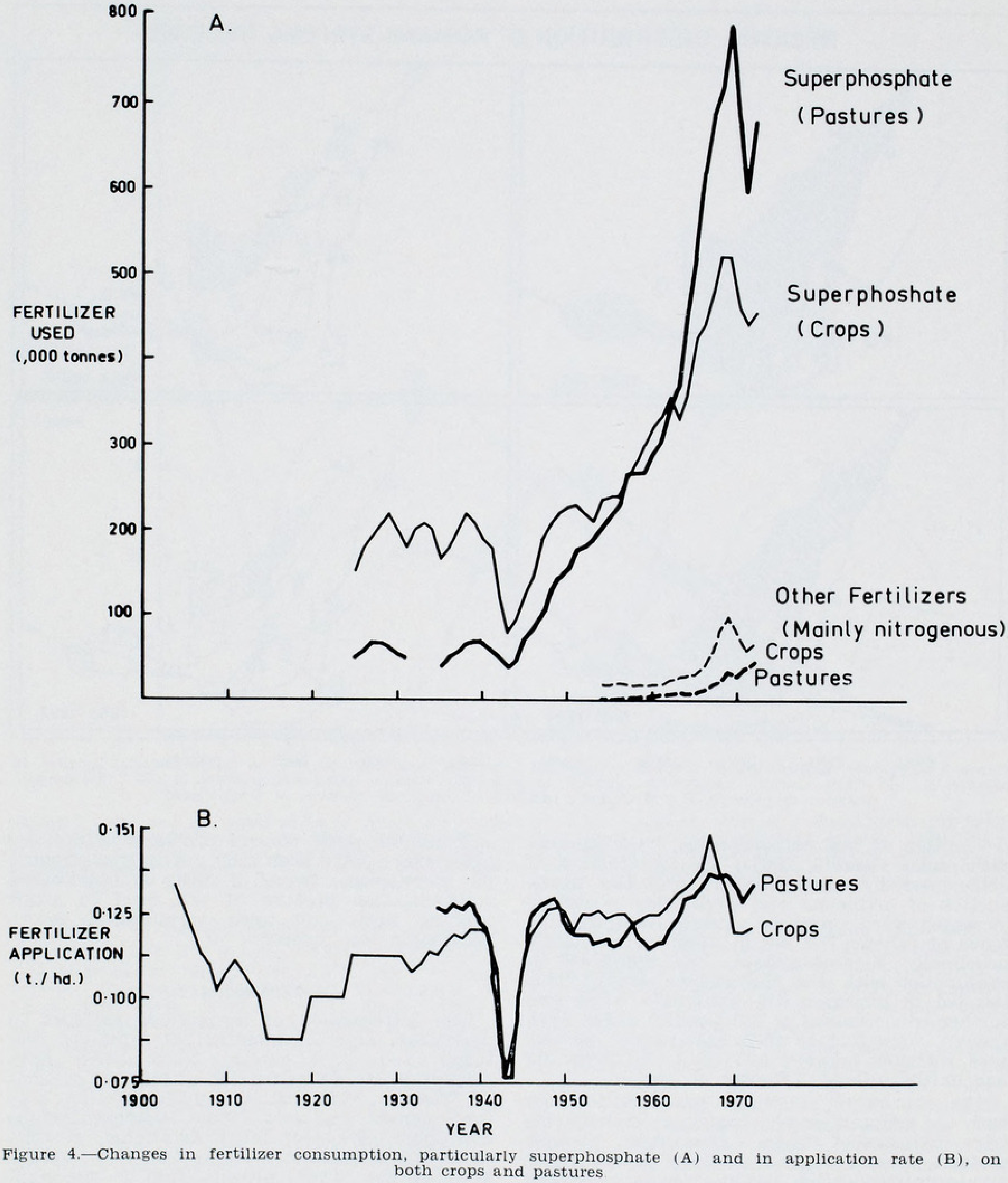

Figure 4.—Changes in fertilizer consumption, particularly superphosphate (A) and in application rate (B), on both crops and pastures

siderations of quality been responsible for directing major changes in cultivar use. Unpublished data indicate that whilst the currently popular cultivar (Gamenya) is over 20% more productive than its predecessor (Bencubbin) under crop-pasture rotations, these cultivars are of equivalent performance if planted early on fallow. In fact Bencubbin was still being recommended for early planting as recently as 1965, even though its popularity was low (Figure 2). Despite the current and relative yield advantage of Gamenya over Bencubbin district average wheat yields/ha have increased to a more limited extent. This suggests, that the contribution of plant breeding in recent years has been one of developing cultivars more adapted to the changes in cultural practices and farming systems that have taken place.

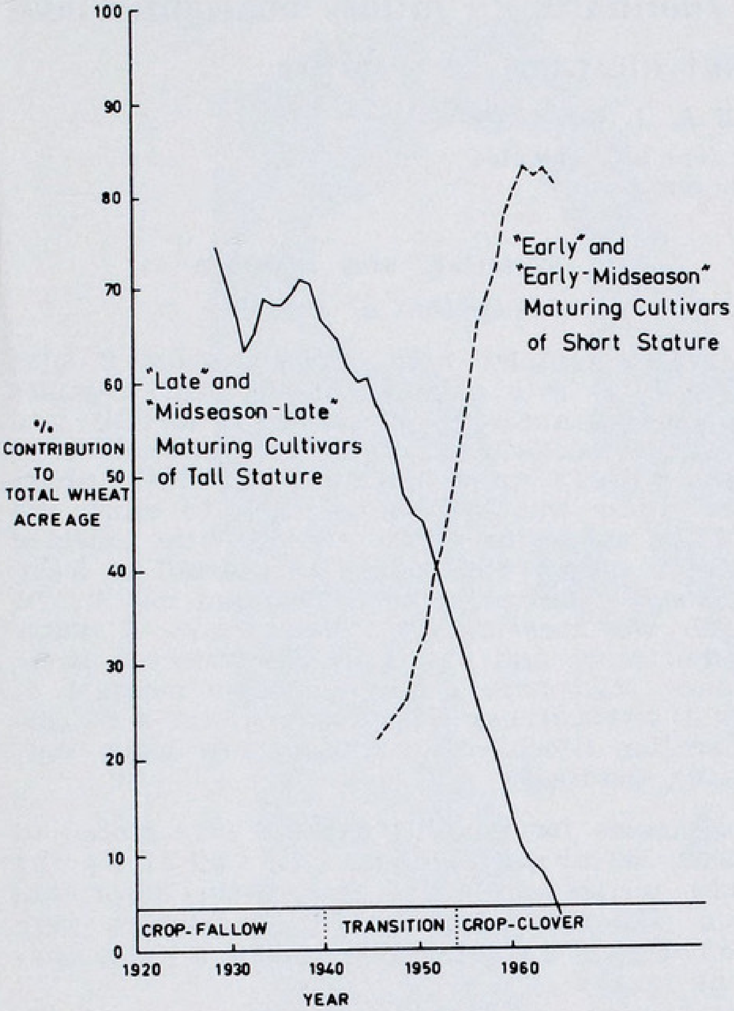

Figure 5.—Changes in the adaptive characteristics of wheat cultivars with changes in cultural practice.

The changes which have occurred illustrate the important ecological principle of a dynamic, and delicate, balance between genotype and environment. Modification of the environment affects the productivity and survival of biological organisms within the biosphere. Man's current concern over his own survival as a consequence of his interference with the environment (e.g. pollution of air and water) stands in sharp contrast to his ancient and continuing need to modify the agricultural environment for the benefit of crops he grows and the livestock he tends. With increasing understanding of plant growth, development and genetics, man has the capacity, through plant breeding, to modify his crop plants to exploit the environmental conditions he can provide for them. The changes in cultural practices discussed in this paper have had the effect of rendering less adaptable and less efficient those cultivars that were once so popular (Figure 2). The continued popularity of Gamenya, despite breeders efforts to improve upon its performance, suggest that additional changes in the crop environment could be a prerequisite to further breeding progress. As the previous changes led to greater diversification of farming systems it is most probable that increased intensification within those systems will now become more urgent.

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